Annals of the Sri Lanka Department of Agriculture 2012. 14: 247-252.

SHORT COMMUNICATION

DETERMINATION OF COOKING PROPERTIES OF RICE (*Oryza sativa* L.) IN RELATION TO THEIR GELATINIZATION TEMPERATURE AND GRAIN TYPE

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INTRODUCTION

Cooking and eating qualities of rice are the most important quality attributes in many rice producing areas of the world (Li *et al.*, 2003) and are determined mainly by its starch properties, which influence the gelatinization temperature (GT), volume expansion and water absorption of rice (Wan *et al.*, 2007). The GT is the temperature at which rice absorbs water and the starch in the grain starts to swell (irreversibly) and varies from species to species, often from cultivar to cultivar. Sri Lankans prefer their cooked rice to be dry, flaky hard and high volume. Juliano *et al.* (1965) reported that the GT influences cooking quality of rice, where rice with a higher GT seem to require a little longer time to cook in automatic rice cookers. Bhattacharya and Sowbhagya (1971) observed that water uptake and hence the cooking time, was strongly influenced by the surface area per unit weight *i.e.* the size and shape of the rice grain, and only marginally by its GT. Batcher (1956) observed that water uptake of rice at boiling temperature is not related to the GT but to the grain size and shape. The GT appears to be directly related to cooking time of rice (Juliano *et al.*, 1992). However, Jianrong *et al.* (2005) stated that the cooking time depends on amount of rice weight and amount of water used for cooking. These controversial statements and the effect of GT of rice on the weight and volume of cooked rice are still not fully clear. This study was aimed at identifying the behavior of rice grains with same shape but varying GT, and different shapes with same GT, during cooking under controlled conditions.

MATERIALS AND METHODS

Nine rice (*Oryza sativa* L.) varieties, representing three categories of grain types (size and shape) and three levels of GT were selected for the study (Table 1). Husked paddy was polished for 75 sec and passed through a sieve to remove broken grains and further separation was done manually. Thousand milled head grains from all treatments were counted using a digital grain counter (model: 6708-Indosaw, India) and weighed separately to determine the thousand grain mass (TGM).

Table 1. Categorization of rice varieties, to grain types and gelatinization temperatures

Grain characteristics			Category		
Grain size (length/mm)			Intermediate (5.00-5.99)	Long (6.00-7.00)	Long (6.00-7.00)
Grain shape (length /width)			Bold (2.00-2.39)	Medium (2.40-3.00)	Slender (over 3.00)
Gelatinization Temperature	*Score*	°C		*Rice varieties*	
High	1 - 3	>74	At 307	At 303	At 593
Intermediate	4 - 5	70-74	Bg 379-2	Bg 94-1	At 306
Low	6 - 7	<70	Bg 403	At 362	At 405

Milled head grains were poured into a 90 ml plastic cup and tapped on a wooden surface for 10 times. Then the excess rice was levelled horizontally with a glass rod, to make the top surface evenly flat. The weight was measured and repeated for five times for raw rice weight (RRW). A total of 50 milled head grains were randomly picked from each sample and held with tweezers. Then the length (L, major axis) and width (W, intermediate axis) of brown rice kernels were measured using a micrometer screw gauge with an accuracy of 0.001 mm. Rice with different GT were considered separately for the preparation of cooking with different rice:water volumes. The water requirement optimum for rice-cooking was determined according to the preliminary studies adopted by Delmundo (1979) and Hafeel (2010). For high, intermediate and low GT categories, the rice:water ratio were 1:2, 1:1½ and 1:1 v/v, respectively.

One cup (90 ml) of rice was transferred to a mini rice cooker (SR-03G National, Japan) of 350 ml capacity with the relevant water volume. Rice was cooked and time was recorded through a stop clock. Cooked rice weight (CRW) was measured in the pre-weighed rice cooker-pan. Further calculations were done to obtain the evaporated water weight (EWW) and absorbed water weight (AWW). Twenty cooked rice grains were placed on a 1 mm graph paper and the length and width of each grain were measured with an accuracy of 0.5 mm using a hand lens (x4 power). Cooked rice height was measured with an accuracy of 0.5 mm immersing a wooden ruler in to the rice pan at five points immediately after automatic switch off. Pan radius was measured and cooked rice volume (CRV) was calculated. The experiment was arranged in a Complete Randomized Design (CRD) with nine treatments (rice varieties) and three replicates. Data were analyzed using

ANOVA and means were compared using Duncan's Multiple Range Test (DMRT) at p=0.05.

RESULTS AND DISCUSSION

Rice varieties showed significantly ($p<0.05$) different TGM and RRW values (Table 2). The mass of 1,000 grains differed according to the variety, its origin, etc. (Baumans, 1985). The LM varieties showed a significantly higher ($p<0.05$) TGM than other six varieties of IB or LS. The highest RRW was recorded in the rice variety Bg 403 (78.07 g) followed by At 307 and Bg 379-2. Due to good packing behaviour of IB grain types, high RRW of a constant volume was observed. Results presented in Table 2 show that the highest similar CRW of high GT varieties and the significance of CRW among intermediate GT varieties. Although low GT were cooked with the same volume of water (90 ml), the CRW of Bg 403 was significantly higher ($p<0.05$) than that of At 362 and At 405. This may be due the high packing ability of Bg 403 shown by its high RRW compared to other varieties.

Table 2. Mass values of raw and cooked rice and other attributes of nine rice varieties

Rice variety	*Grain type*	*GT score*	*TGM (g)*	*RRW (g)*	*CRW (g)*	*AWW (g)*	*EWW (g)*	*CT (s)*	*RRL (mm)*	*RRWt (mm)*	*CRL (mm)*	*CRWt (mm)*	*L in %*	*Wt in %*	*CRV (cm^3)*
At 307	IB	1	16.58^{g} *	75.86^{b} *	200.17^{a} *	124.33^{b} *	62.33^{a} *	1428^{a} *	4.91^{e*}	2.50^{a*}	8.07^{g*}	3.27^{a*}	64^{bc*}	30^{a*}	257^{ab*}
At 303	LM	2	19.15^{c}	72.80^{d}	200.80^{a}	128.00^{a}	64.33^{a}	1445^{a}	6.31^{bc}	2.22^{b}	8.67^{f}	3.17^{a}	38^{f}	42^{a}	241^{bc}
At 593	LS	1	15.40^{i}	73.37^{cd}	199.83^{a}	126.33^{ab}	52.33^{bc}	1448^{a}	6.69^{a}	1.73^{d}	10.93^{a}	2.17^{b}	64^{c}	24^{abc}	264^{a}
Bg 379-2	IB	4	17.90^{e}	75.03^{b}	171.43^{c}	96.33^{d}	50.00^{c}	1300^{b}	4.95^{e}	2.50^{a}	8.33^{g}	3.17^{a}	68^{b}	25^{ab}	249^{abc}
Bg 94-1	LM	5	19.42^{a}	72.53^{d}	164.33^{d}	92.00^{e}	54.67^{b}	1264^{bc}	6.14^{c}	2.27^{b}	9.90^{bc}	2.90^{a}	61^{c}	29^{a}	234^{cd}
At 306	LS	5	17.29^{f}	74.33^{bc}	179.13^{b}	105.00^{c}	42.67^{d}	1211^{c}	6.44^{ab}	1.87^{c}	10.07^{b}	2.07^{b}	56^{d}	10^{bc}	240^{bc}
Bg 403	IB	7	18.28^{d}	78.07^{a}	152.17^{e}	74.00^{f}	29.00^{f}	860^{d}	5.32^{d}	2.47^{a}	9.50^{de}	2.75^{a}	76^{a}	8^{bc}	216de
At 362	LM	7	19.27^{b}	74.43^{bc}	140.47^{f}	66.00^{h}	35.00^{e}	895^{d}	6.04^{c}	2.23^{b}	9.37^{e}	3.10^{a}	54de	37^{a}	206^{e}
At 405	LS	7	16.10^{h}	73.40^{cd}	142.03^{f}	68.67^{g}	30.67^{f}	838^{d}	6.47^{ab}	1.88^{c}	9.77^{cd}	2.00^{b}	51^{e}	7^{c}	219de

* Mean ; Mean values of each variety within a column with different letters are significantly different at $p<0.05$.

GT – Gelatinization temperature, IB- Intermediate bold, LM- Long medium, LS- Long slender, TGM- Thousand grain mass, RRW- Raw rice weight of 90 ml volume, CRW–Cooked rice weight, AWW–Absorbed water weight, EWW – Evaporated water weight, CT – Cooking time, RRL- Raw rice length, RRWt- Raw rice width, CRL–Cooked rice length, CRWt–Cooked rice width, Lin – percentage length increase, Win – percentage width increase, CRV – Cooked rice volume

Among the three varieties of intermediate GT category, the variety Bg 94-1 showed the lowest RRW. Due to poor packing ability of Bg 94-1, a lower number of grains packed in 90 ml cup has resulted in lower RRW leading to lower CRW compared to other two varieties with the same GT. Bhattacharya and Sowbhagya (1971) explained the strong influence made by grain size and shape (the surface area per unit weight) on the water uptake. More water was absorbed and evaporated when cooking high GT varieties than intermediate and low GT. With the increase in the added weight of water to cook rice, the absorption and evaporation of water during cooking was higher (Table 2). According to Juliano *et al.* (1992), GT appears to be directly related to duration of cooking rice. The high GT varieties had taken significantly more time to cook rice compared to intermediate and low GT varieties. The results are in agreement with findings of Juliano *et al.* (1965) who reported that the rice with higher GT require a little longer time to cook in automatic rice cookers. However, in contrast, Bhattacharya and Sowbhagya (1971) reported that cooking time was strongly influenced by the surface area per unit weight of rice and only marginally by its GT.

The CRW and CRV of high GT varieties were higher than those of intermediate and low GT varieties. Higher water volume (180 ml) used to cook these varieties might have influenced the CRW and CRV. Cooked rice grain length and width differed significantly between varieties. Batcher (1956) has observed that water uptake of rice at boiling temperature is not related to the GT but to the grain size and shape. Varieties used in this study performed differently on grain length or width elongation during cooking. No exact pattern in elongation with GT or grain shapes was observed. However, a proportional width-wise elongation of all varieties was noted. The width of raw rice LS varieties (2.00-2.17 mm) were significantly lower ($p<0.05$) than that of IB and LM (2.75-3.27 mm) varieties where cooked rice width showed a similar trend in significance. The variety Bg 403 has increased its grain length by 76 % during cooking even with lower volume of water (90 ml), compared to high GT varieties with higher volume of water (180 ml).

The higher CRW of Bg 403 compared to other two low GT varieties could be explained by its highest increase in CRL (76 %) as well as by the higher AWW within the same low GT group. However, the increase in width of Bg 403 was lower compared to other varieties. Bhattacharya and Sowbhagya (1971) explained the strong influence made by grain size and shape (the surface area per unit weight) on water uptake and cooking time. The variety At 593 had a CRV of 264 cm^3, which was similar to the CRV of At 307 and Bg 379-2 and the lowest CRV were reported by varieties in the low GT group.

CONCLUSIONS

The grain weight represented by thousand grain mass has no influence on the weight or volume of cooked rice. Added volume of water according to the gelatinization temperature (GT) of the rice variety influences its cooked weight, volume and cooking time. However, the grain type with a good packing ability offers a higher raw rice weight, which would lead to a higher cooked rice weight within its GT group. Increments observed in grain dimensions of cooked rice did not show any clear pattern with their GT. Therefore, a study with more number of varieties representing different GT categories and grain types is suggested.

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